NAVY ENERGY R&D PROGRAM SUMMARY FY 1979-FY 1984

U.S. NAVY ENERGY AND NATURAL RESOURCES
RESEARCH AND DEVELOPMENT OFFICE

NAVY ENERGY R&D PROGRAM SUMMARY FY 1979-FY 1984

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CHIEF OF NAVAL MATERIAL

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U.S. NAVY ENERGY AND NATURAL RESOURCES
RESEARCH AND DEVELOPMENT OFFICE
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CONTENTS

LIST OF TABLES

LIST OF FIGURES

NAVY ENERGY R&D PROGRAM SUMMARY
FY 1979-FY 1984

OVERVIEW

Through its energy research and development (R&D) program, the Navy is identifying and assessing promising technological solutions to the Navy's operational energy problems by:

- Developing and maintaining its status as an informed customer for new energy technologies being developed with government support or by industry.
- Applying energy technology to hardware and systems that are unique to Navy mission requirements.
- Building an energy technology base in areas essential to the Navy's mission where the technology is not being developed elsewhere.

The Navy energy R&D program was developed by the Navy Energy and Natural Resources R&D Office (MAT-08T3), assisted by the Navy Systems Commands (SYSCOMs) and laboratories. The R&D program supports the overall Navy energy program directed by the Navy Energy Office (OPNAV-413) and described in *Navy Energy Plan and Program 1978.*

Guidance for the Navy's energy program and energy R&D program is provided by the National Energy Plan and Executive Order 12003, as well as by policy formulation groups of the Office of the Secretary of Defense (OSD).

NAVY ENERGY SITUATION

Factors affecting the Navy's current and projected energy situation can be summarized as follows:

- National security depends on the ability to guarantee the availability of energy supplies and meet essential industrial and military requirements.
- Seventy-three percent of the energy required by the Navy is derived from petroleum. (See Figures 1, 2, and 3 for current Navy energy consumption data.)
- Liquid hydrocarbons will continue to be the primary fuels required by Navy aircraft and most surface ships through 2000.
- Since 49 percent of the nation's oil requirements is imported, the Navy is dependent on foreign oil supplies; its missions are therefore susceptible to political or strategic actions.

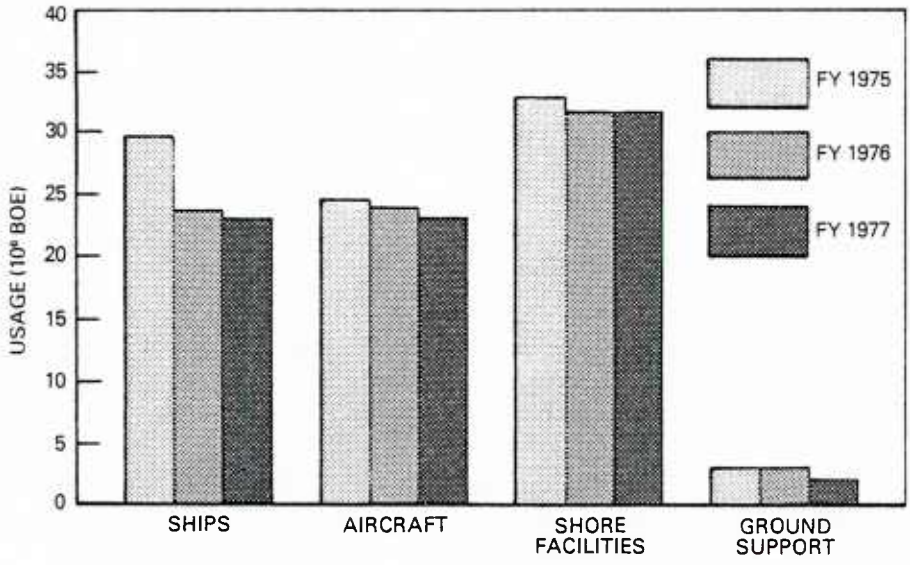

Figure 1. NAVY ENERGY USAGE BY ACTIVITY

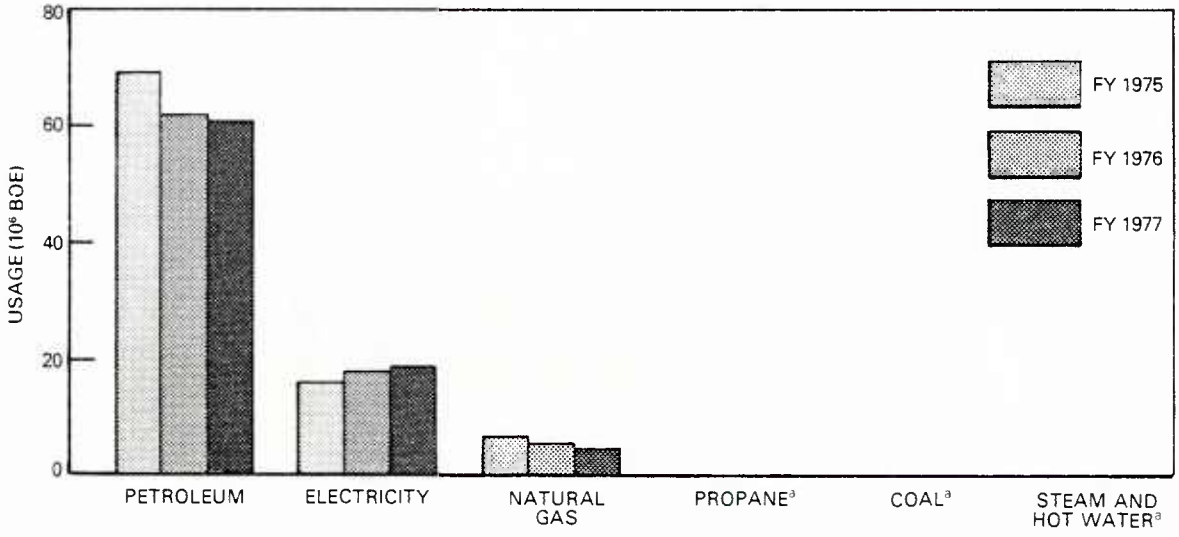

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Figure 2. NAVY ENERGY USAGE BY ENERGY FORM

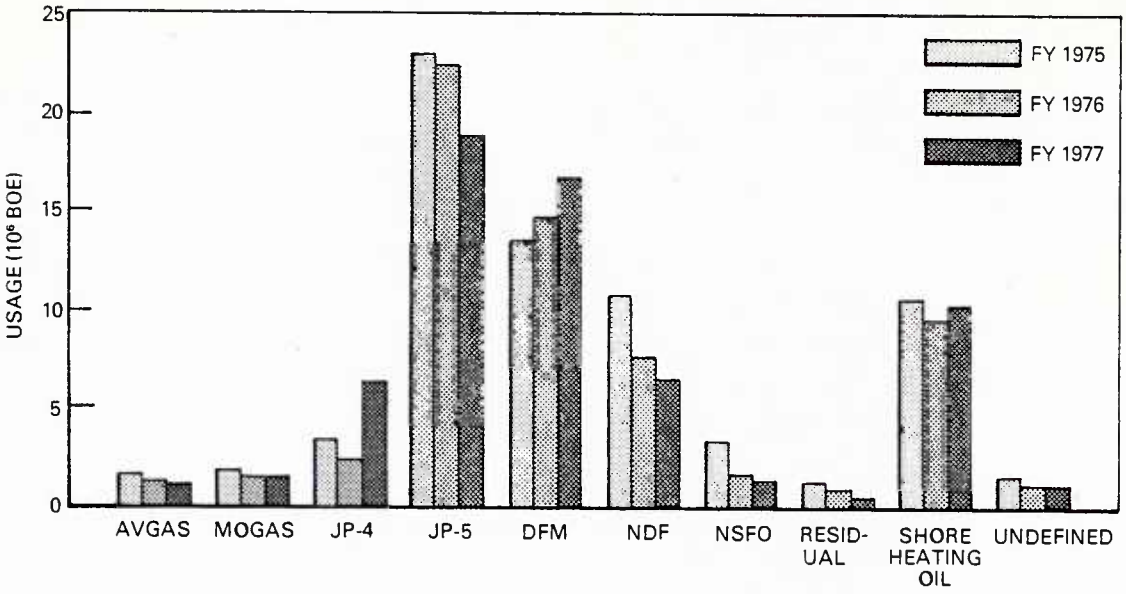

Figure 3. NAVY PETROLEUM ENERGY USAGE BY FUEL TYPE

- Synthetic fuels derived from oil shale, coal, and tar sands offer the best long-term assurance of naval liquid fuel availability from domestic resources.
- The cost of acquiring energy is increasing rapidly. For the Navy, the purchase cost totaled $1.3 billion in FY 1977, and may total $2.7 billion (in FY 1977 dollars) by 2000.
- Current national energy policy to reduce dependence on foreign oil includes programs and goals for energy conservation, increased use of domestic coal, and the development of technologies to use other sources such as synthetic liquid hydrocarbons and renewable energy sources.

Therefore, the Navy has identified several requirements:

- Energy conservation technology must be applied to Navy systems to reduce energy use without adversely affecting fleet readiness and training.
- The Navy must develop the capability to operate on and become an informed customer for fuels produced wholly or in part from domestic fossil fuel resources (coal, oil shale, and tar sands) and fuels of broadened specifications to avoid compromising fleet readiness when conventional military specifications fuels are in short supply or unavailable.
- To decrease reliance on petroleum and increase energy self-sufficiency at Navy bases, coal and renewable energy sources must be used where technically and economically feasible.

NAVY ENERGY OBJECTIVES, GOALS, AND STRATEGIES

The Navy has established general energy objectives to ensure that Navy energy policies and programs are directed toward meeting future mission requirements. These objectives are to:

- Achieve maximum practical energy conservation for facilities and operations, with particular emphasis on conservation of petroleum and natural gas.
- Substitute, when economically practical, more abundant or renewable energy sources where petroleum products are now used.
- Consider the effect of energy policy and actions on the health, welfare, and safety of Navy personnel and the environment.

The Navy energy goals, as specified in OPNAV Instruction 4100.5A, apply to reducing the use (or savings) of energy from the FY 1975 baseline (1 October 1974 through 30 September 1975) by the end of 1985:

- Existing facilities—20 percent energy-use reduction per gross square foot of building floor area.
- New facilities—45 percent energy-use reduction per gross square foot to be achieved in all new construction design specifications measured relative to FY 1975 designed average energy consumption per gross square foot.
- Fifteen percent reduction in energy consumption by ground support equipment.
- Twenty percent reduction in fossil fuel energy consumption per ship underway steaming hour.
- Ninety percent reduction in fleet and shore fuel surveys.
- Five percent reduction in fossil fuel energy consumption per flight hour.
- Nine percent energy savings per year by 1985 through aircraft simulator substitution.
- Substitution of more abundant or renewable energy forms for petroleum or natural gas used ashore, culminating in a total substitution of 10 percent. (This goal increased from 5 percent per current OSD direction.)

The five key strategies selected to achieve these objectives and goals focus on:

- Energy conservation, which involves eliminating the inefficient and wasteful use of energy and applying more energy-efficient systems.
- Synthetic fuels, which involves ensuring that Navy ships and aircraft can operate on fuels that may be produced wholly or in part from crudes derived from domestic fossil fuel resources (oil shale, coal, and tar sands) and that Navy shore facilities can also use these alternative fuels to meet some of their energy needs.
- Energy self-sufficiency, which involves developing a level of local self-sufficiency for Navy shore facilities through the use of alternative energy sources, such as solar and geothermal, to prevent mission degradation caused by domestic or worldwide petroleum energy shortages.
- Energy distribution and allocation, which supports a worldwide system of storage,

distribution, and allocation of energy supplies for Navy forces to prevent mission degradation caused by domestic or worldwide petroleum energy shortages.

- Energy management planning, which involves initiating a comprehensive Navy energy resource management structure to conduct short-, mid-, and long-term planning, continuously review programs and priorities, and take action to attain Navy energy goals and minimize adverse effects of energy problems.

NAVY ENERGY R&D PROGRAM

Of the five strategies defined above, three have technology implications that require R&D support. Conservation, synthetic fuels, and self-sufficiency, therefore, are the bases of the Navy energy R&D program. Each of the three strategies, as described below, has its own specific R&D direction and objectives aimed at supporting the achievement of the Navy's overall energy objectives and goals. Tables 1, 2, and 3 list current projects in these three strategies; Table 4 lists energy management and analytical support projects. (The tables begin on page 10.)

Energy Conservation

Energy conservation R&D objectives are to:

- Test and evaluate shore-based systems that will use energy more efficiently.
- Test and evaluate more efficient propulsion and auxiliary systems for the existing and future fleets, and methods for reducing hull drag in Navy vessels.
- Test and evaluate modifications in operational concepts, tactics, and equipment that will reduce fuel usage in aircraft systems (for both current inventory aircraft and advanced designs).

Energy conservation is the only significant near-term solution to the decreasing availability of energy sources and is, therefore, a major part of the Navy's R&D program.

Synthetic Fuels

Synthetic fuels R&D objectives are to:

- Determine the characteristics of military fuels produced wholly or in part from synthetic crudes.
- Conduct test and evaluation programs and apply appropriate engineering expertise to ensure that fuels produced wholly or in part from synthetic crudes are compatible with Navy hardware.
- Certify fuels derived wholly or in part from synthetic crudes for military use and issue specifications and fleet implementation guidelines.
- Develop a capability to operate on fuels of broader specifications when fuels of current military specifications are in short supply.

There are extensive plans for synthetic fuels R&D, with the Department of Energy (DOE) providing the primary impetus in the development of a synthetic fuels industry. The Navy's focus in synthetic fuels R&D is to ensure that the fuels resulting from various government and industry-sponsored synthetic fuels programs will be suitable for Navy needs. The Navy and DOE have joint programs to acquire, refine, test, and evaluate synthetic fuels. As the fuels become available in sufficient quantities, the Navy will ensure compatibility between the synthetic fuels and Navy equipment through testing programs. The Navy is also assessing the feasibility and possible cost advantages of operating on fuels of broader specifications than currently used by the military. This effort will require determining rela-

tionships between fuel chemistry and physical properties as well as the effects of fuel properties on equipment performance. The results of this work will be directly applicable to synthetic fuels R&D.

Energy Self-sufficiency

Energy self-sufficiency R&D objectives are to:

- Test and evaluate alternative and advanced energy systems to reduce the use of petroleum products.
- Utilize renewable/alternative sources of energy such as combustible waste, geothermal, wind, solar, and other sources where available.
- Select and demonstrate the most cost-effective technologies for energy self-sufficiency.
- Promote energy self-sufficiency through continued development of technical expertise in energy systems.

In its self-sufficiency activities, the Navy is applying energy systems and developing energy resources at its bases, using conventional and advanced technologies in the best possible mix that is economically, environmentally, and strategically sound. Extensive R&D programs in solar, wind, geothermal, coal, and waste utilization technologies are being pursued in the civilian sector by DOE, the Environmental Protection Agency (EPA), Electric Power Research Institute, and many other government and private sector organizations. These programs can provide hardware and concepts that the Navy can adopt with minimum effort for use at shore facilities to reduce reliance on petroleum fuels.

Individual energy R&D projects must meet several tests to be included in the Navy energy R&D program:

- Energy technologies being studied must have clear applicability to Navy systems.
- Projects must be fully coordinated within DOD and with the national program, and must not be wastefully duplicative of other efforts.
- Project efforts must show a high probability of offering a positive monetary payback or of providing a new capability commensurate with cost.

R&D PROGRAM MANAGEMENT

MAT-08T3 was established within the headquarters of the Naval Material Command (NAVMAT), specifically within the organization of the Deputy Chief of Naval Material for Acquisition (MAT-08), to plan, budget, and execute the Navy energy R&D program. This office directly controls use of the 6.2—Exploratory Development, 6.3—Advanced Development, 6.4—Engineering Development, and 6.5—Management and Analytical Support funds provided for energy R&D.

MAT-08T3 also influences use of 6.1—Basic Research funds by the Office of Naval Research and Naval Research Laboratory; use of other 6.2, 6.3, 6.4, and 6.5 funds available in the Navy; and, through cooperative agreements with other agencies, use of federal funds that can provide benefits related to the Navy's energy goals.

Technical responsibilities in the Navy have traditionally followed the "platform" lines of ships, aircraft, and shore facilities. For that reason, lead SYSCOMs and laboratories have been designated to assist NAVMAT in formulating and executing the energy R&D program. These assignments are:

Platform	SYSCOM	Laboratory	Scope
Ships	NAVSEA	David W. Taylor Naval Ship R&D Center	Total ship program involving conservation and synthetic fuels
Aircraft	NAVAIR	Naval Air Development Center	All aircraft conservation aspects
		Naval Air Propulsion Center	All aircraft synthetic fuels aspects
Shore facilities	NAVFAC	Civil Engineering Laboratory	Total shore facilities program involving conservation, synthetic fuels and self-sufficiency

Higher supervisory levels involved in the Navy energy R&D program are:

- Office of the Assistant Secretary of the Navy for Research, Engineering and Systems.
- Navy Energy Office (OP-413), in the Office of the Deputy Chief of Naval Operations, Logistics (OP-04).
- R&D Coordinator (OP-098G), in the Office of Director, RDT&E (OP-098).

Figure 4 is a simplified chart of the Navy energy planning organization.

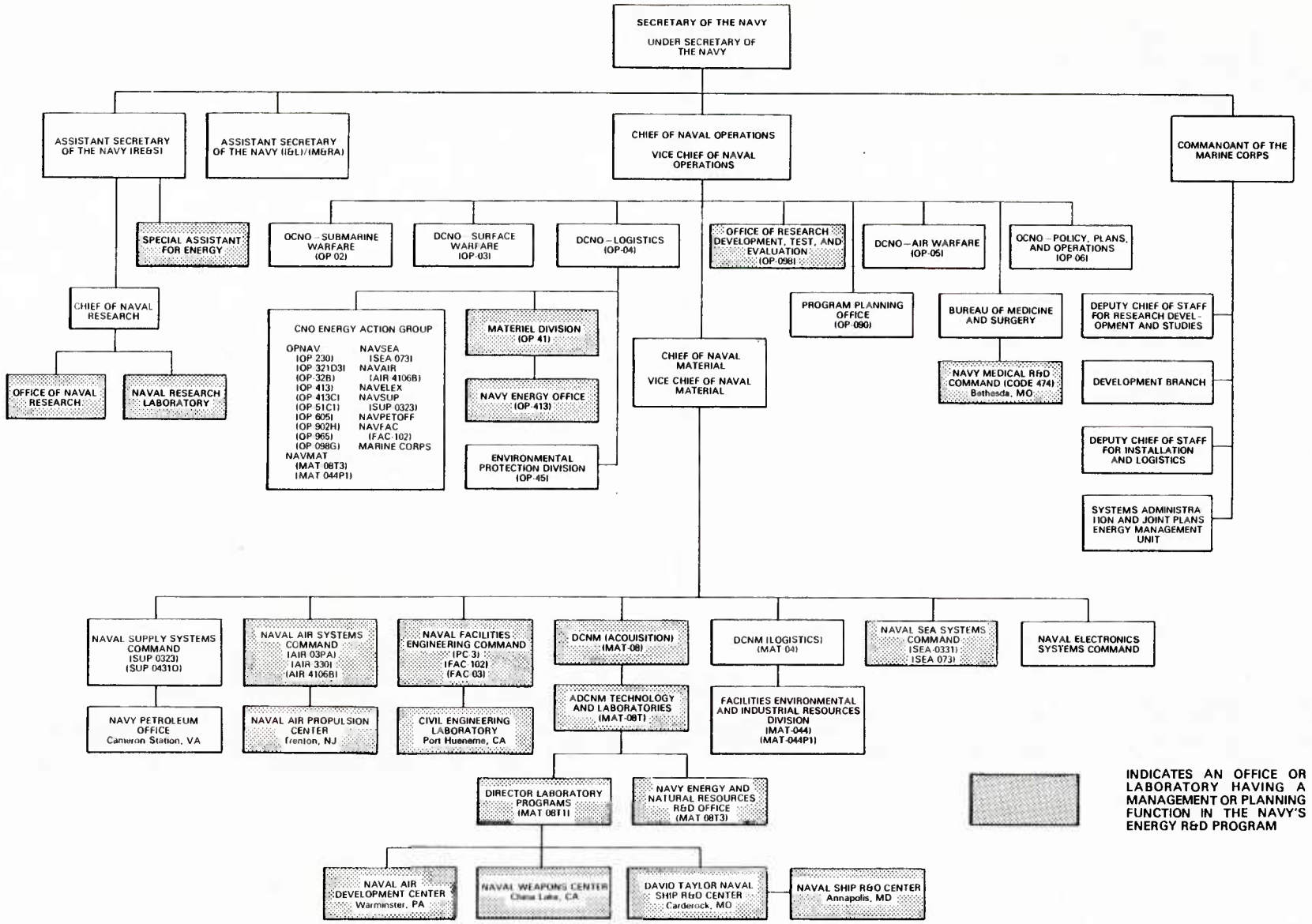

Figure 4. DEPARTMENT OF THE NAVY ENERGY PLANNING ORGANIZATION

Table 1. ENERGY CONSERVATION PROJECTS

Title and Description	Performer
SHIPS	
Underwater Hull Claaning Reduce fuel consumption of Navy ships through the periodic removal of biofouling from underwater surfaces.	DTNSRDC
Noncoating Biofouling Protection Develop a method to prevent the attachment of marine organisms to the interiors of sea chests during in port periods when the steam plan is inactive.	DTNSRDC
Improvad Hull Coatings Reduce fuel consumption of Navy ships through the elimination of biofouling from ship hulls for 5 years by development of an improved antifouling coating.	DTNSRDC
Speciel Application Coatings Develop coatings which remain fouling free while maintaining structural integrity on the high-performance surfaces of sonar dome intakes and propellers.	DTNSRDC
Mechinery Optimizetion Identify energy-intensive machinery systems and operating procedures aboard major classes of existing ships and recommend modifications to reduce fuel consumption.	DTNSRDC
Stack Gas Analyzer Develop a feed-back regulated control system based upon the oxygen analysis principle to maintain boiler combustion air at predetermined levels over all conditions of demand.	DTNSRDC
Low Excass Air Burner Improve the combustion efficiency of naval boilers through tha development and incorporation of low excess air burner designs.	DTNSRDC
Stendby Main Faed Pump Provida a standby feed pump with the capability of accelerating from the cold standby condition of full operating capacity in sufficient time to protect the propulsion boilers in the event of main feed pump failure.	DTNSRDC
Improvad Economizar Improve cycle efficiency and thereby reduce fuel consumption of the 1,200 psig steam plants of tha FF 1052/1078 and similar class ships through tha addition of another stage of feed heating by modification or replacement of existing economizer.	DTNSRDC
Machinery Performanca Monitoring Enable shipboard engineering personnel to maintain ships plants at peak efficiency by providing diagnostic information on plant condition in terms of off-optimum operations and machinery plant degradation.	DTNSRDC
Not Undarway Steeming Identify and develop energy savings alternatives to steaming a main boiler while not under way to provide shipboard auxiliary steam requirements.	DTNSRDC
Water Resourca Managamant Identify freshwater flow patterns and formulate water resource management techniques to improve the efficiency of freshwater production and utilization aboard ship.	DTNSRDC
Hull and Hull Appendeges Improvaments Minimize the energy consumption attributable to Navy ship hull and hull appendage designs.	DTNSRDC
Propulsor (Hull Extarnal) Dasign Improvamants Identify and evaluate both existing and new design of ship propulsors that may reduce power loss and increase propulsive efficiency of surface combatants.	DTNSRDC
Ship Propulsion Systams (Hull Internal) Minimize the fuel consumption of the main propulsion system over the ships operational profile, without compromising the ships' mission capabilities.	DTNSRDC
Ships Sarvica Elactric Powar Identify and develop less energy-intensive ships service electric systems for the near, mid, and far terms.	DTNSRDC
Auxiliary Machinary Identify and develop less energy-intensive Navy shipboard auxiliary systems for the near, mid, and far terms.	DTNSRDC
Total Energy Identify cost-effective options for shipboard energy systems which will minimize fuel consumption.	DTNSRDC
Flaet Design Support Make available to new ship design programs and existing ship overhaul/modernization projects, a source of expertise for the conduct of energy trade-off studias, economic analyses and ship impact assessments.	DTNSRDC
AIRCRAFT	
Aircreft Fuel Conservetion Anelysis Program Analyze the fuel used by USN/USMC aircraft by type and mission and study means to reduce fuel use by design changes/modifications and/or mission performance.	NADC
SHORE FACILITIES	
Thermal Enginaaring of Buildings Adapt technologies developed in conjunction with the national program to reduce thermal losses in Navy buildings. Projects include:	
• **Construction Mathods end Matariels.** Determine thermal, structural, safety, and related characteristics of new construction methods and materials.	CEL
• **Metarials Properties Compilation.** Catalog the thermal properties, conformance to ASTM standards, O&M characteristics for newer energy-conservative materials and techniques.	CEL
• **Thermel Loads Pradiction.** Monitor and exercise current versions of selected computer programs developed under joint national sponsorship for Navy application.	CEL
• **Maasurement of Building Enargy Losses.** Evaluate and test instrumentation and techniques to locate and measure energy losses from buildings.	CEL
• **Polyurathana Foam Roofing Systams.** Determine optimum polyurethane roofing systems and maintenance procedures for new applications on Navy facilities.	CEL

Table 1. ENERGY CONSERVATION PROJECTS (Cont'd)

Title and Description	Performer
• **Instrumentetion Peckeges for Field Surveys.** Determine suitable instrumentation and formulate users guide for conducting field surveys.	CEL
• **Vepor end Air Infiltretion Berrier Design.** Explore potential joint Navy-DOD effort to investigate candidate vapor barrier materials and determine their potential effectiveness in Navy applications.	CEL
Low Energy Structures Apply LES technology to new and existing buildings at Navy facilities. Projects include:	
• **Above Ground Low Energy Structures.** Identify promising structural concepts for minimizing energy consumption for retrofit and new construction at Navy shore facilities by monitoring the national energy program.	CEL
• **Subterreneen Low Energy Structures.** Through monitoring and coordinating with the national energy programs, define and analyze selected concepts applicable to Navy sites.	CEL
• **Eveluation of Existing Low Energy Structures.** Survey existing structures and record architectural/structural energy conserving concepts utilized by government and industry.	NWC
• **Louvered Atrium Building Concept.** Verify, through operation, the performance characteristics, and determine the life-cycle cost of the louvered atrium concept as applied to Navy buildings.	CEL
Advenced HVAC Systems Identify HVAC systems for application to Navy buildings. Projects include:	
• **High-Performence Heet Pumps for Heet Recovery.** Investigate alternative heat pump systems suitable for Navy use, and coordinate with federal programs.	CEL
• **Efficient HVAC Systems et Pert-Loed Operetion.** Investigate retrofit of existing Navy air conditioning systems to employ part-load design principles developed in prior work, maintain information exchange with DOE.	CEL
• **Seewetер Cooling for Buildings.** Explore joint Navy-DOE effort to design, construct, install, and instrument a demonstration seawater cooling system for naval shore facilities at NSGA, Winter Harbor, Maine.	CEL
Power Generetion Facilities Identify Navy applications of power generation conservation concepts. Projects include:	
• **Cogeneretion Systems.** Survey potential application of cogeneration at selected Navy shore activities and recommend sites for study/application.	CEL
• **Orgenic Renkine Diesel Bottoming Cycle.** Prepare preliminary design, test plan, equipment selection, and obtain all necessary agreements for a joint Navy-DOE demonstration of an ORC system.	CEL
• **Meesurement of Energy Losses in Pipelines.** Study, procure, and test leak detection instruments for above and underground pipelines; coordinate with DOE, Army, and Air Force.	CEL
Electricel Systems Apply latest technology to Navy lighting systems. Projects include:	
• **Lighting Technology.** Investigate lighting advances impacting on energy conservation and lighting quality.	CEL
• **Lighting Applications.** Implement lighting synthesis computer program on Navy computer.	CEL
• **Electric Systems.** Explore joint DOD-DOE effort to test electrical equipment and power systems to determine and verify capabilities for electrical conservation at Navy shore facilities.	CEL
• **Detection end Meesurement of Energy Losses in Electricel Distribution Systems.** Conduct field tests at selected Navy bases using IR equipment, power factor meters, corona detection meters and other instruments to determine location and extent of losses; correlate with findings of national program.	CEL
Energy Monitoring end Control Systems Ensure EMCSs installed in Navy facilities are most up to date and energy-efficient possible, and determine potential for retrofitting installed but unfunctioning EMCSs. Projects include:	
• **Retrofit of NRMC Hospitel EMCS.** Install a high technology EMCS at NRMC, Long Beach	CEL
• **Locel HVAC Control Loop Improvements.** Develop guidelines for local control improvements as alternatives to central control to meet Navy needs for reduced energy consumption and maintenance; coordinate with DOE, Army, and Air Force.	CEL
• **Selection and Applicetion Guidelines.** Develop selection and economic analysis principles for Navy EMCS application.	CEL
• **EMCS Modules/Microprocessor Time Clock.** Identify and develop specialized applications of microprocessors to energy monitoring and control.	CEL
• **Lerge-Scale EMCS.** Demonstrate performance and economics of distributed processing and advanced EMCS.	CEL
• **EMCS New Technology.** Investigate new developments in computer hardware and software, and develop EMCS algorithms for special Navy needs.	CEL

Table 2. SYNTHETIC FUELS PROJECTS

Title and Description	Performer
SHIPS	
Fuels Properties Evaluate synthetic fuels for use in Navy weapon systems by laboratory analyses of specifications, physical and chemical characterization, and upgrading investigations. Perform assay analyses of synthetic crude for DFM and alternative product yields. Investigate other synthetic fuel sources.	DTNSRDC
Fual Flaxibility Construct a uniform set of procedural criteria for evaluating the effects of alternative fuels, conventional and synthetic, on system performance, safety, reliability, maintainability, and logistics.	DTNSRDC
Toxicology Determine the nature and quantities of airborne contaminants which will result from using synthetic fuels in Navy ships, assess the consequential health hazards, and recommend precautions.	DTNSRDC
Synfuel Testing Determine the suitability of alternative fuels for use in naval boilers, diesel engines and gas turbines through small-scale combustor testing, full-scale engine testing, fuel system components compatibility testing, and sea trials.	DTNSRDC

Title and Description	Performer
AIRCRAFT	
Enargy Conversion/Synthatic Fuels Evaluate physical and chemical characteristics of nonspecification and synthetic JP-5, including reactivity, storage stability, and conformity to specifications. Investigate compatibility, performanca, safety hazards, and handling requirements.	NAPC NRL
Aircraft Engine Tasting of Synthetic Fuels Determine the effects of using synthetic JP-5 in tests with TF30, TF34, and othar Navy engines. Conduct flight test with F-14 aircraft.	NAPC
Saa-Going Sarvica Evaluation of Synthatic Aviation Fuals for Navy Usa Perform final qualification of synthetic JP-5 fuel verifying compliance with maximum performance requirements under conditions of actual carrier-dependent aircraft oparations. Develop handling and safety expertise.	NAPC
SHORE FACILITIES	
Wasta Oil/Fual Oil Blands Verify the ability to burn high concentrations of waste oil blended with fresh oil in stationary Navy boilers.	CEL
Liquid Fual Flexibility in Navy Shora Boilars Expand the capability of Navy shore boilers to utilize a wide range of conventional and synthetic fuel oils.	CEL

Table 3. ENERGY SELF-SUFFICIENCY PROJECTS

Title and Description	Performer
Soler Heeting end Cooling Evaluate feasibility of using solar heating and cooling systems and solar-augmented heat pumps in Navy HVAC applications. Projects include:	
• **Recommended Soler Heeting Systems.** Continue data acquisition from AEUTB, compare predicted and measured system performance, and update for solar heating.	CEL
• **Recommended Soler Cooling Systems.** Investigate solar cooling systems for feasibility for Navy applications.	CEL
• **Soler Augmented Heet Pump.** Install and test SAHP in AEUTB and investigate storage techniques.	CEL
Soler Electric Systems Evaluate solar electric conversion systems, such as photovoltaic systems. Projects include:	
• **Soler Air Turbine Demonstration.** Prepare preliminary design of Brayton cycle system in support of DOE small solar thermal power system program.	CEL
• **OOE Photovolteic Power Systems Demonstretion.**	CEL
Soler Deselination Prepare preliminary designs of full-scale solar desalination plants.	CEL
Energy Storege Identify, test, and evaluate high-energy density, low-cost dissolved salts and chemical energy-storage methods. Projects include:	
• **Dissolved Salts Storege.** Evaluate dissolved salts storage concepts for Navy solar energy applications.	CEL
• **Chemicel Storege of Thermel Energy.** Evaluate chemical energy storage concepts for Navy solar energy applications.	CEL
• **Energy Storege Applicetions.** Define Navy energy storage requirements and monitor energy storage applications contract.	CEL
Wind Generetor Systems Investigate use of wind generators to displace consumption of fossil fuels at Navy facilities. Projects include:	
• **Smell WTG-Power-to-Grid Applicetion.** Evaluate 6 kW WTG at AEUTB and 20 kW WTG at Kaneohe.	CEL
• **Smell WTG-Non-Grid Navy Applicetions.** Evaluate 2 kW WTG at AEUTB and 5 kW WTG at San Nicolas Island for building power supply applications.	CEL
• **Remote Nevy Site WTG Demonstretion.** Acquire wind characteristics data at Pinon Point, NWC.	CEL
• **DOE Lerge-Scele WTG Applicetion Studies.** Collect cost and performance data for a 100 to 200 kW unit and initiate site evaluation procedures.	CEL
Coel Utilizetion Identify most economically and technically feasible methods and systems for using coal to supply power at Navy facilities. Projects include:	
• **Anelysis of Advenced Coel Burning Options.** Apply industry and national technologies to Navy shore systems.	CEL
• **Industriel Size Boiler Consolidetion for Conversion to Coel Firing end Cogeneretion.** Incorporate large boiler research as applicable to smaller Navy boilers.	CEL
Energy from Solid Weste Identify most economically and technically feasible methods and systems for efficient recovery and burning of solid waste at Navy bases. Projects include:	
• **Heet Recovery Incineretors.** Collect test and evaluation data on commercial systems at two Navy bases to determine optimum conditions for Navy use.	CEL
• **Solid WDF Processes.** Determine physical characteristics of WDF fuels for burning in heat-recovery incinerators or for firing with coal. Evaluate economics of total system, including collection and transportation of refuse.	CEL
Geothermel Energy Identify Navy bases on or near promising geothermal energy resources and determine methods for encouraging development of resource. Projects include:	
• **Coso Resource Eveluetion.** Conduct flow test of production well, resolve legal/institutional barriers, develop public health and environmental criteria for Coso area.	NWC
• **Adek Resource Eveluation.** Monitor heat flow in exploratory well, conduct further geophysical studies, drill deep slim hole.	NWC USGS
• **Eveluetion of Sites Pest Adek.** Conduct geophysical, geochemical, and heat flow studies at NAS, Fallon, Imperial Valley Region, and Lualualei/Kaneohe/Bellows Region.	NWC USGS DOE
• **Geothermel Legel/Institutional Studies Other Then Coso.** Identify and resolve issues affecting Navy facilities and activities.	NWC
• **Geothermal Utilization Technology.** Identify, adapt and test geothermal energy technology being developed elsewhere for application at Navy sites.	NWC
• **Geothermel Corrosion Studies.** Study the effect of geothermal effluents on military communications and electronic equipment.	NWC
Optimel Plenning of Energy Systems Provide planning information and economic analyses to assist EFDs. Projects include:	
• **Energy Plenning end Optimizetion Model.** Provide the base facilities planning information and economic analyses necessary to optimize the application of alternative energy systems mixed with conservation practices and alternative energy sources.	CEL
Site Cherecteristics Provide information necessary for applying energy technologies to Navy bases. Projects include:	
• **Compiletion of On-Site Energy Resource Dete.**	CEL
• **Dete Compiletion for Energy Consumption.**	CEL
• **Fecilities end Lend Aveilability for Energy Use.**	CEL
• **Energy Dete Mobile Leboretory Implementation.**	CEL
• **Energy Engineering Progrem Monitoring.**	CEL

Table 4. ENERGY MANAGEMENT AND ANALYTICAL SUPPORT PROJECTS

Title and Description	Performer
SHIPS	
Energy Profile Anelysis Maintain, update, and report Navy energy usage and projections for future usage.	DTNSRDC
Fuel Stripping Develop means to recover fuel normally lost in tank operations because of ship material and/or fuel management deficiencies.	DTNSRDC
SHORE FACILITIES	
Sewell's Point End-Use Meesurement Determine site characteristics of Sewell's Point Naval Base to characterize energy usage.	CEL
Pacific Missile Test Center Self-Sufficiency Study Prepare a self-sufficiency plan for PMTC showing time-phased conversion to on-base renewable energy sources.	CEL
Navel Weepons Center Self-Sufficiency Study Prepare a self-sufficiency plan for NWC showing time-phased conversion to on-base renewable energy sources.	CEL

PROGRESS IN ENERGY R&D PROJECTS

Energy Conservation

Ships

Underwater Hull Cleaning

The accumulation of fouling on ship's hulls and appendages causes the single largest fuel consumption penalty, resulting in losses of as much as one-third in propulsion efficiency. Periodic hull cleaning may reduce annual ship fuel consumption by 8 percent. Most sea trials have been completed and candidate hull cleaning systems have been evaluated. Interim cleaning instructions have been issued to fleet units and contractual provision for the fleetwide program is provided for FY 1979.

Hull Coatings

Improved antifouling hull coatings are being developed as a sequel to the hull cleaning project to achieve the full benefits of a fouling-free hull (an estimated annual ship fuel consumption reduction of 16 percent). Reduced drydock time, increased speed, and significantly reduced fuel costs are expected to result from such coatings, which are based on organometallic polymer (OMP). Screening of initial OMP paint formulations has been completed and two candidates have been selected for ship trials on a West Coast ship. One hull in the Pacific has been painted with test stripes.

Biofouling Prevention

Accumulation of biofouling in the main seawater system sea chest and grating while ships are not underway may restrict inlet water flow when the ships resume underway status and adversely affect propulsion performance. The Navy has completed laboratory tests of selected ultrasonic transducer designs and operating parameters, and has demonstrated the feasibility of using the ultrasonic designs in field tests using simulated sea chests off Panama City, Florida. Transducer system electronics have been optimized to greatly reduce power requirements.

Improvement of Shipboard Machinery Efficiencies

The Navy is pursuing a program to identify, document, and quantify the energy intensive machinery systems and operational procedures aboard major ship classes, and to recommend modifications to effect major energy savings. Data obtained during sea trials and from sensitivity and economic analyses have resulted in identification of the following projects for steam-powered vessels:

- *Combustion Optimizer.* The use of a combustion optimizer to maintain boiler combustion air at predetermined levels is being considered. This optimizer has the potential for saving in excess of 1 million barrels of fuel annually. Two systems that measure volumetric oxygen percentage by different methods of sampling stack gases are being tested.

- *Low Excess Air Burners/Improved Economizers.* The Navy is investigating the feasibility of increasing boiler efficiency by reducing excess air requirements or, alternatively, by improving heat transfer characteristics. Implementation of either one of these approaches is projected to save over 400,000 barrels of fuel annually in Navy steam vessels.
- *"Cold Start" Main Feed Pump.* Boiler feedwater is supplied by main feed pumps, but because of the critical nature of the water supply, standby feed pumps are kept idling constantly, resulting in a considerable expenditure of energy. The Navy has projected that retrofitting ships with "cold start" feed pumps is cost-effective; a prototype will be tested.
- *Machinery Performance Monitoring.* Specifications have been prepared for procurement of a system that provides diagnostic information on plant conditions and will enable shipboard engineering personnel to maintain ships' machinery plants at peak efficiency, and thus maximize opportunities for significant fuel savings.

Improvement of Shipboard Auxiliary Machinery Efficiencies

Auxiliary machinery—such as ship service electrical systems; freshwater systems; pumping systems; heating, ventilating, and air conditioning (HVAC); and lighting—consumes major amounts of fuel. HVAC systems, along with pumping and lighting systems, account for 60 percent of the fuel consumed for electric power generation aboard ship. The Navy is seeking to identify alternative electrical concepts that will reduce energy consumption and life-cycle costs of equipment. Quiet diesel and improved gas-turbine-powered generating systems are being evaluated, with the quiet diesel as the baseline. Concepts are being developed to reduce fresh water consumption, which currently exceeds the 30 gallons/man-day allowance, to 20 to 25 gallons/man-day. Efforts are being made to determine how new or revised pump designs can save energy without sacrificing effectiveness. Sources of alternative fuel-conserving HVAC equipment have been identified and several system concepts have been selected for further analysis. New lighting concepts are being investigated, and analysis, test, and evaluation of 20 watt fluorescent ballasts have begun.

Aircraft

The Naval Air Development Center is investigating ways to conserve energy during the operation of current inventory Navy aircraft. Mission/functional analyses are conducted to identify alternative operational tactics and/or payloads or advance designs that could result in energy savings. During 1977–78, the operational characteristics of patrol and search aircraft were surveyed. A program to investigate simple design retrofits for improved efficiency has also been initiated.

Shore Facilities

Advanced Energy Utilization Test Bed

The Naval Facilities Energy Command has constructed a specially configured house to serve as an Advanced Energy Utilization Test Bed (AEUTB) for testing field measurement

methodologies and system concepts for energy conservation in buildings, and for conducting experiments on infiltration, leak detection, lighting, HVAC, and energy monitoring and control systems (EMCSs). Highlights of some of these and other conservation projects follow.

Polyurethane Foam Roofing Systems

The Navy has approximately 62 million square feet of metal roofing, 22 million square feet of which may be heated and/or cooled, and could be waterproofed and insulated with spray-applied polyurethane foam. The effects of applying polyurethane foam to metal roofing are being studied at the Civil Engineering Laboratory (CEL), including fire safety factors, effects of aging on the thermal efficiency of polyurethane foam, and the optimum materials and methods for maintaining foam roofing systems.

Energy Monitoring and Control Systems

Reductions of up to 50 percent of energy usage are achievable with EMCSs. CEL is studying the cost-effectiveness, operational capabilities, relative utilization of system features, operation and maintenance and other related parameters for both existing and advanced EMCSs. The use of computerized systems for analyzing load performance and optimizing control strategies is also being investigated. Two sites are being metered to provide energy data before designing and installing retrofitted EMCSs. To identify new sensors and controls that are applicable to Navy needs, the Navy is surveying manufacturers, architects, engineers, and consulting firms.

HVAC Energy Consumption

An estimated 35 percent of the Navy's total shore energy bill is for heating and cooling buildings. Continuing studies at CEL of advanced HVAC systems include investigating options such as heat pumps and increasing the part-load efficiency of existing air conditioning systems through simple retrofit actions. These investigations deal with the technical feasibility, potential savings, and potential markets for alternative HVAC systems in the Navy shore establishment. A seawater air conditioning system is being evaluated, and the feasibility of a joint Navy-DOE program to demonstrate the system is being explored.

Building and Pipeline Energy Losses

The Navy is evaluating instrumentation and instrument packages to locate and quantify energy losses from steam, air, water, and gas pipelines, as well as from Navy buildings. For both pipelines and buildings, infiltration measurements are made with a tracer gas. Aerial and ground infrared survey techniques and equipment are being used to detect losses in Navy buildings and steam lines. Close liaison is being maintained with the National Bureau of Standards for measurement standardization.

Organic Rankine Bottoming Cycle for Diesels

This program, cosponsored by the Navy and DOE, will demonstrate the efficiency of a central power plant using a low-temperature heat-recovery system (an organic Rankine bottoming cycle) at the diesel electric power plant at the Naval Air Station (NAS) in Bermuda. The purpose is to evolve organic Rankine heat-recovery equipment suitable for the military environment.

Cogeneration

The generation and distribution of steam (or hot water) is part of the utility program at practically all Navy facilities. Electrical power is generated at quite a few bases also. Centralizing these activities using cogeneration would reduce energy requirements for producing and distributing steam and electricity. Under this project, more than 20 bases in the continental United States were identified as potential cogeneration sites. The Jacksonville NAS/Naval Air Rework Facility was selected as the site for an exemplar cogeneration study.

Synthetic Fuels

Engine Testing with Synthetic Fuel Products

The suitability of alternative fuels for use in naval boilers, diesel engines, and gas turbines is to be determined through tests in small-scale combustors, full-scale engines, and fuel system components, as well as in sea trials. The Navy began investigating the feasibility of using synthetic fuels in military equipment in 1974 when synthetic crude derived from coal at the Char-Oil Energy Development pilot plant was provided to the Navy by the Department of the Interior for testing as a ship fuel. Sea trials, conducted on the U.S.S. Johnston using fuel produced from this crude, demonstrated the potential of using synthetic fuels for Navy applications.

In 1974, the Navy served as the lead agency for a joint DOD, NASA, Coast Guard, Maritime Administration (MARAD), and Energy Research and Development Administration (ERDA) project to refine and test fuels derived from 10,000 barrels of crude shale oil. The fuel types produced were gasoline, JP-4, JP-5/Jet A, DFM/DF-2, and heavy fuel oil. These fuels were tested at various government and industry laboratories.

Navy test and evaluation efforts included:

- Tests of DFM in a single-burner boiler, a three-cylinder diesel, and an NTCC-350 six-cylinder diesel engine. Its performance compared favorably with that of petroleum-derived DFM.
- Gas turbine tests using DFM, conducted by Detroit Diesel Allison, Pratt and Whitney, and General Electric.
- Conduct of a TF34 30.9 hour engine test using JP-5 derived from shale oil. Engine performance at sea-level conditions and altitude starting were equivalent to the performance of petroleum-derived JP-5.

This 10,000 barrel oil shale project culminated in the successful operational flight of a T-39 jet aircraft by the Air Force; the successful operational cruise of the Great Lakes steamer, Edward B. Green, sponsored by the Navy, MARAD, and Coast Guard; and the operational testing of a jeep (L-141) engine by the Army. These tests clearly demonstrated the feasibility of using crude shale oil as a feedstock for military fuels, particularly those in the middle-distillate range (jet and diesel fuels).

As a follow-on to the 10,000 barrel shale oil refining and testing project, the Navy is serving as the contracting agency and project director for a joint DOD-DOE-NASA program, which began in 1976, to acquire, refine, and test fuels derived from shale oil produced by the Paraho process on the Naval Oil Shale Reserves near Rifle, Colorado. From January 1977 through September 1978, 88,225 barrels of crude shale oil were produced under Navy and DOE contracts in support of this program. Between October 1978 and February 1979, the shale crude was refined into military specification fuels for testing by the military services and other agencies.

A computerized file of reports relating fuel properties and engine performance was developed and a methodology for extracting and filing engine test data formulated. Sources of additional fuel performance data were located within other government agencies, and some engine manufacturers.

Experimental combustor tests were completed on JP-5 derived from tar sands, oil shale, coal, and petroleum in which chemical and physical properties were controlled to deviate from JP-5 specification limits in specific ways. Flame radiation (which affects durability) and smoke varied as a function of hydrogen/carbon ratio for all fuels, except that coal derived fuel was slightly higher in these properties than would be expected from the trend of the other fuels.

Fuel Properties

Synthetic fuel crude samples, acquired from various pilot demonstration and commercial sources, are screened through the tests required by the appropriate military specification (MILSPEC), for example, JP-5 and DFM. On the basis of these screening tests, candidate fuels are characterized by physical and chemical properties. Crude assay analyses of various synthetic crudes are conducted to determine the potential yield and quality of MILSPEC fuels. These analyses are conducted in cooperation with DOE and other Department of Defense (DOD) laboratories. In addition to operational fuel considerations, these assay analyses will further identify potential sources of other synthetic products (such as lubricants and hydraulic fluids) of interest to the Navy.

Crude assays have been performed on samples of shale oil crude from seven sources and six coal-derived liquids. Refined fuels have been analyzed to determine their compliance with or deviation from MILSPEC requirements. Fuels studied included those derived from oil shale, tar sands, and coal, and particularly the DFM and JP-5 products from the 10,000 barrel shale oil experiment. In addition, type analyses, upgrading studies, and wear and comparability evaluations were conducted on some fuels. Physical and chemical property determinations were started on samples of each of the refined products from the recent production of Paraho shale crude.

A study of the basic nitrogen compounds in shale oil JP-5 has continued. The study showed that concentration of 50 ppm basic nitrogen will cause a fuel to fail the thermal stability requirement, but that substituted pyridines are not deleterious at concentrations of 100 ppm. These data are being used in support of the joint DOD-DOE-National Aeronautics and Space Administration (NASA) shale oil refining program, indicating the severity of the refining required to achieve an acceptable nitrogen level. Thermal stability studies are also being conducted with a single tube of an aircraft heat exchanger to establish the losses in heat exchanger effectiveness resulting from deposit levels produced by fuels of varying thermal oxidation stability. These data will be used to assess stringency of the current level of thermal stability as required by the JP-5 specification.

Fuel Flexibility

The Navy's ability to maintain full operational readiness is to be ensured by having available sufficient alternative fuel sources during circumstances of reduced availability or embargo of the principal military specification fuel supplies. In addition, criteria for evaluating the effects of alternative fuels, conventional and synthetic, on system performance, safety, reliability, maintainability, and logistics are to be established, and information is to be generated for planning future engine systems and fuels-handling equipment which have fewer constraints on fuel properties. Work statements were prepared to procure contractual services to develop alternative fuels evaluation procedures for both Navy ship and aircraft engine systems.

A study of the effects of emergency fuels on aircraft performance was conducted with the blending of 10 percent and 20 percent of two different batches of DFM with JP-5 fuel. Evaluation of the physical properties for JP-5 showed that these blends had acceptable viscosity. The freezing point and thermal oxidation stability, however, were unacceptable by a large margin. Fuel control and coalescer tests will be run on neat DFM (the worst case). A T63 engine performance/exhaust emission test will be conducted with a 20 percent DFM blend. A contract to evaluate the combustion properties of broad specification JP-5, and blends of DFM with JP-5 and gasoline using a T63 combustor was awarded. The fuel/air ratios for ignition and blowout, flame radiation, exhaust smoke, and combustor performance for these fuels were measured.

Synthetic Fuel Toxicology

Shipboard atmospheric sampling has been conducted to determine the concentration and characteristics of hydrocarbon vapors in the working spaces aboard ships. The data will be used to estimate the concentrations to be expected during the use of synthetic fuels. Candidate synthetic liquid fuels are being examined by the U.S. Naval Medical R&D Command for possible toxic effects. The results of this work, when combined with vapor concentration estimates, will be used to determine potential health effects and recommend any procedures or precautions that might be needed when operating with synthetic fuels.

Liquid Fuel Flexibility in Navy Shore Boilers

The capability of Navy boilers is to be expanded to allow firing of a wider range of fuel

oils. Test programs are being conducted in Navy shore boilers with mixtures of waste fuels and fresh fuel oils. The objective of this work is to develop guidelines for the safe and economical use of waste oil at Navy shore facilities.

Firing tests were conducted using blends of up to 100 percent contaminated distillate fuels in heavy (No. 5) fuel oil, blends of up to 50 percent used lubricating oils in light (No. 2) fuel oil, straight used lubricating oils with 0.4 percent and 4.4 percent suspended water, and contaminated diesel fuel. Test results generally show that waste oil blends can be fired satisfactorily in boilers without appreciable difference from regular fuel oil firing. Minor adjustments are sometimes required to compensate for effects resulting from possible viscosity variations.

Energy Self-sufficiency

Geothermal Energy

Use of geothermal energy to produce power and supply space heating will reduce dependence on petroleum at Navy installations as well as increase the level of self-sufficiency. With DOE and the U.S. Geological Survey carrying out the major effort, the Navy is encouraging the development of geothermal resources that can economically supply electrical power or space heating to Navy facilities. For example, development is being planned of extensive geothermal resources at COSO, Naval Weapons Center (NWC), China Lake, where geothermal power production could save as much as 160,000 barrels of oil equivalent per year and supply power to surrounding DOD facilities as well. Navy geothermal exploration continues at COSO and DOE has drilled a 1,575 meter production size well there; the highest temperature recorded to date was 196 °C. The Navy is assembling data and conducting analyses to identify specific Navy requirements and problems associated with geothermal energy development on or near a Navy base. Several reports and study results have been prepared on legal, institutional, and environmental issues, as well as on the physical effects of corrosive brines on military equipment. An Environmental Impact Statement was filed with EPA in November 1978, and a contract will be awarded in December 1979 for development using private industry and private capital. The plant is scheduled to be operational in 1984. Exploratory wells have also been drilled at Adak, Alaska; heat flow tests are being conducted on these wells.

Conversion of Solid Waste

A large portion of solid waste produced at Navy bases is combustible. Research at CEL, in coordination with EPA, focuses on adapting technologies for economic extraction of energy from small quantities of solid waste. Since the Navy uses steam networks in about 50 percent of its shore facilities, conversion of the combustible refuse into steam energy is considered to be a feasible alternative to disposal of waste into expensive landfills. For example a commercial packaged heat-recovery incinerator is being tested at NAS, Jacksonville, and at Norfolk.

Coal Use

The National Energy Plan and other federal mandates focus on a significant increase in the use of coal. Moreover, the use of coal at Navy shore facilities would allow the Navy to reserve more of its petroleum supplies for ships and aircraft.

To supplement completed studies on coal utilization, the Navy has awarded a contract for analyzing and ranking coal-use options at Navy facilities. Study results to date suggest that direct firing of coal in large central steam plants is the most economical method of using more coal at Navy bases. Site-specific feasibility studies also are being conducted. Developments in coal use, which are estimated to become more technically and economically feasible in the future, are being monitored. The Navy is supporting DOE's planned demonstration of an atmospheric fluidized-bed boiler to be constructed in 1980 at the Naval Training Center, Great Lakes.

Solar Energy

Solar technologies being studied by CEL deal with solar heating and cooling systems, solar electric systems such as solar air turbines and photovoltaics, and solar desalination systems. Commercial solar collectors as well as solar heating and hot water systems are being tested in the AEUTB. Solar desalination systems are being evaluated for water supply at remote bases where fresh water is scarce. These studies have resulted in selection of two concepts for testing. A program plan has been written for testing and applying photovoltaic power equipment at Navy bases; this work is being coordinated with DOE demonstration programs.

COOPERATIVE ENERGY TECHNOLOGY AND DEMONSTRATION PROJECTS WITH OTHER FEDERAL AGENCIES

To further assist in meeting its requirements as a major energy user, the Navy serves as a cosponsor with other federal agencies in joint energy technology development and demonstration programs. Most of the cooperative agreements for these programs call for the use of the Navy operational environment for testing and demonstrating new energy technologies. Testing and demonstrating these technologies will speed commercialization in the civilian sector and allow the Navy to maintain the fuel supplies necessary to execute its role in national defense.

When agreement is reached on the scope of a joint project, a Memorandum of Understanding (MOU) is prepared and approved by the Navy and the appropriate agency. Interaction between the Navy and a cosponsoring agency with respect to a given project may take several forms: exchange of technical information; sharing of resources, such as personnel, facilities, or equipment; and joint funding of a project. The transfer of funds or the sharing of resources is documented in a project-specific Interagency Agreement (IA). The following sections describe how the cooperative agreements with various federal agencies support the Navy's three energy R&D strategies.

Energy Conservation

The Navy shares considerable common interest with other federal agencies in meeting the energy conservation goals specified in Executive Order 12003. The Navy also maintains close cooperative relationships with those federal agencies responsible for developing the various conservation technology segments of the national energy program. Within the framework of these relationships, the Navy conducts its applied R&D program to meet its energy conservation goals for ships, aircraft, and shore facilities.

Department of Energy

Under a DOD-DOE agreement, the Navy has cosigned three MOUs with the major divisions of DOE responsible for conservation technology. This exchange of information and developed technology is expected to be useful for Navy facilities, while also providing some benefit to ships and aircraft. The areas of technical interest outlined in the MOUs with the three DOE divisions are:

- Division of Fossil Fuel Utilization, Energy Technology
  - — Components and heat engines
  - — Heat utilization
  - — Fuel cells
  - — Combustion
  - — Materials and fabrication
  - — Thermodynamics and heat transfer
  - — Controls and process efficiency
- Division of Industrial Energy Conservation, Conservation and Solar Applications
  - — Industrial processes